

What is Claimed:

- 1 1. A composition for treating the surface of a ferrous metal, the
2 composition comprising:
 - 3 a) at least one of aluminum sulfate and an aluminum sulfate
4 precursor;
 - 5 b) at least one of boric acid and a boric acid precursor; and
 - 6 c) at least one of a polycarboxylic acid and a polycarboxylic acid
7 precursor.
- 1 2. The composition of claim 1, wherein said at least one of a
2 polycarboxylic acid and a polycarboxylic acid precursor comprises at least one of
3 oxalic acid and a water-soluble salt of oxalic acid.
- 1 3. The composition of claim 2 further comprising a second
2 polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of
3 adipic acid and azelaic acid.
- 1 4. The composition of claim 1, wherein said at least one of a
2 polycarboxylic acid and a polycarboxylic acid precursor comprises at least one of
3 citric acid and a water-soluble salt of citric acid.
- 1 5. The composition of claim 4 further comprising a second
2 polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of
3 adipic acid and azelaic acid.

- 1 6. The composition of claim 1 further comprising a polyol.
- 1 7. The composition of claim 6, wherein said polyol comprises at
2 least one of trimethylolpropane, pentaerythritol, and dipentaerythritol.
- 1 8. The composition of claim 6, wherein said polyol comprises at
2 least one of trimethylolpropane and pentaerythritol.
- 1 9. The composition of claim 1 further comprising at least one of L-
2 aspartic acid and D-aspartic acid.
- 1 10. The composition of claim 1 further comprising glutamic acid.
- 1 11. The composition of claim 1, wherein said aluminum sulfate, said
2 at least one of boric acid and a boric acid precursor, and said at least one of a
3 polycarboxylic acid and a polycarboxylic acid precursor are present in the following
4 amounts:
- 5 a) between about 40 wt.% and about 80 wt.% of aluminum
6 sulfate;
- 7 b) between about 10 wt.% and about 20 wt.% total of at least one
8 of boric acid and a boric acid precursor; and
- 9 c) between about 10 wt.% and about 20 wt.% total of at least one
10 of a polycarboxylic acid and a polycarboxylic acid precursor.

- 1 12. The composition of claim 11 further comprising:
- 2 d) between about 5 wt.% and about 10 wt.% of citric acid;
- 3 e) between about 2 wt.% and about 5 wt.% of pentaerythritol;
- 4 f) between about 2 wt.% and about 5 wt.% of adipic acid; and
- 5 g) between about 1 wt.% and about 3 wt.% of L-aspartic acid.
- 1 13. A composition for treating the surface of a ferrous metal, the
- 2 composition comprising:
- 3 a) between about 50 wt.% and about 70 wt.% of aluminum
- 4 sulfate;
- 5 b) between about 10 wt.% and about 15 wt.% of boric acid;
- 6 c) between about 5 wt.% and about 15 wt.% of oxalic acid;
- 7 d) between about 2 wt.% and about 7 wt.% of citric acid;
- 8 e) between about 2 wt.% and about 7 wt.% of adipic acid;
- 9 f) between about 1 wt.% and about 5 wt.% of pentaerythritol;
- 10 g) between about 1 wt.% and about 5 wt.% of
- 11 trimethylolpropane;

- 12 h) between about 0.5 wt.% and about 2 wt.% of azelaic acid; and
- 13 i) between about 1 wt.% and about 5 wt.% of L-aspartic acid, D-
- 14 aspartic acid, or a mixture thereof.

1 14. A method for treating the surface of a ferrous metal, comprising

2 contacting the surface of a ferrous metal with an aqueous mixture comprising:

- 3 a) aluminum sulfate;
- 4 b) boric acid; and
- 5 c) a polycarboxylic acid.

1 15. The method of claim 14 further comprising bringing said

2 aqueous mixture to a temperature between about 150°F and about 210°F.

1 16. The method of claim 14 wherein the pH of said aqueous mixture

2 is between about 1 and about 4.

1 17. The method of claim 14, wherein the contacting step comprises

2 contacting the surface of the ferrous metal with the aqueous mixture for a period of

3 time between about 1 minute and about 15 minutes.

1 18. The method of claim 17, wherein said period of time is between

2 about 2 minutes and about 10 minutes.

1 19. The method of claim 14, wherein said ferrous metal is a low-
2 carbon steel, and wherein the contacting step comprises contacting the surface of the
3 ferrous metal with the aqueous mixture at a temperature between about 185°F and
4 about 200°F.

1 20. The method of claim 14, wherein said ferrous metal is a
2 medium-carbon steel, and wherein the contacting step comprises contacting the
3 surface of the ferrous metal with the aqueous mixture at a temperature between
4 about 170°F and about 200°F.

1 21. The method of claim 14, wherein said ferrous metal is a high-
2 carbon steel, and wherein the contacting step comprises contacting the surface of the
3 ferrous metal with the aqueous mixture at a temperature between about 160°F and
4 about 200°F.

1 22. The method of claim 14, wherein said aqueous mixture further
2 comprises at least one of L-aspartic acid and D-aspartic acid.

1 23. The method of claim 14, wherein said polycarboxylic acid
2 comprises at least one of oxalic acid and citric acid.

1 24. The method of claim 14, wherein said aqueous mixture further
2 comprises a polyol.

1 25. The method of claim 14, wherein said aqueous mixture further
2 comprises at least one of adipic acid and azelaic acid.

1 26. A ferrous metal treated by the method of claim 14.

1 27. An aqueous mixture for treating the surface of a ferrous metal,
2 the mixture comprising:

3 a) aluminum sulfate;

4 b) boric acid; and

5 c) a polycarboxylic acid.

1 28. The aqueous mixture of claim 27 having a pH between about 1
2 and about 4.

1 29. The aqueous mixture of claim 27, wherein said polycarboxylic
2 acid comprises oxalic acid.

1 30. The aqueous mixture of claim 29 further comprising a second
2 polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of
3 adipic acid and azelaic acid.

1 31. The aqueous mixture of claim 27, wherein said polycarboxylic
2 acid comprises citric acid.

1 32. The aqueous mixture of claim 31 further comprising a second
2 polycarboxylic acid, wherein said second polycarboxylic acid comprises at least one of
3 adipic acid and azelaic acid.

1 33. The aqueous mixture of claim 27 further comprising a polyol.

1 34. The aqueous mixture of claim 33, wherein said polyol comprises
2 at least one of trimethylolpropane, pentaerythritol, and dipentaerythritol.

1 35. The aqueous mixture of claim 33, wherein said polyol comprises
2 at least one of trimethylolpropane and pentaerythritol.

1 36. The aqueous mixture of claim 27 further comprising at least
2 one of L-aspartic acid and D-aspartic acid.

1 37. The aqueous mixture of claim 27 further comprising glutamic
2 acid.

1 38. The aqueous mixture of claim 27, wherein said aluminum
2 sulfate, said boric acid, and said polycarboxylic acid are present in the following
3 relative amounts, exclusive of added water:

4 a) between about 40 wt.% and about 80 wt.% of aluminum
5 sulfate;

6 b) between about 10 wt.% and about 20 wt.% of boric acid and a
7 boric acid; and

8 c) between about 10 wt.% and about 20 wt.% total of a
9 polycarboxylic acid.

1 39. The aqueous mixture of claim 38 further comprising:

- 2 d) between about 5 wt.% and about 10 wt.% of citric acid;
- 3 e) between about 2 wt.% and about 5 wt.% of pentaerythritol;
- 4 f) between about 2 wt.% and about 5 wt.% of adipic acid; and
- 5 g) between about 1 wt.% and about 3 wt.% of L-aspartic acid.

1 40. An aqueous mixture for treating the surface of a ferrous metal,
2 the composition comprising the following materials in the following relative amounts,
3 exclusive of added water:

- 4 a) between about 50 wt.% and about 70 wt.% of aluminum
5 sulfate;
- 6 b) between about 10 wt.% and about 15 wt.% of boric acid;
- 7 c) between about 5 wt.% and about 15 wt.% of oxalic acid;
- 8 d) between about 2 wt.% and about 7 wt.% of citric acid;
- 9 e) between about 2 wt.% and about 7 wt.% of adipic acid;
- 10 f) between about 1 wt.% and about 5 wt.% of pentaerythritol;
- 11 g) between about 1 wt.% and about 5 wt.% of
12 trimethylolpropane;
- 13 h) between about 0.5 wt.% and about 2 wt.% of azelaic acid; and

- 14 i) between about 1 wt.% and about 5 wt.% of L-aspartic acid, D-
15 aspartic acid, or a mixture thereof.

1 41. A method for making an aqueous mixture for treating the
2 surface of a ferrous metal, the method comprising mixing together in any sequence
3 the following materials:

- 4 a) at least one of aluminum sulfate and an aluminum sulfate
5 precursor;
- 6 b) at least one of boric acid and a boric acid precursor;
- 7 c) at least one of a polycarboxylic acid and a polycarboxylic acid
8 precursor; and
- 9 d) water.

10 42. The method of claim 41 further comprising bringing the pH of
the aqueous mixture to between about 1 and about 4.